THE
Malayan Agricultural Journal.

Vol. XVII. JUNE, 1929. No. 6.

Observations on the Dwarf Coconut Palm in Malaya.

By H. W. Jack & W. N. Sands.

Introduction.

The three dwarf and closely allied races of the coconut palm, which are of increasing economic importance locally, are those with ivory-yellow, apricot-red and green fruits respectively. These palms were fully described by us in a previous paper (1) where also, the results of certain observations and experiments that had been made in connection with their vegetative and flowering characters were given. It was shown that the flowers were, as a rule, self-pollinated, and that a high percentage of the resulting fruits bred true to type even when exposed to cross-pollination. It was also shown that it was possible to make a fairly accurate separation of the dwarf races from hybrid and tall forms by noting the growth and the colour characters of young plants in the nursery.

For the purpose of obtaining additional information concerning the palms, fruits of each of the three races were obtained in June, 1921, from open pollinated palms in a large plantation where dwarf forms were mainly grown. The nuts were germinated in Kuala Lumpur and afterwards transferred to Parit Buntar in the State of Perak where they were planted in the compound of the office and store of the Botanical Division of the Department of Agriculture. The soil there is an

(1) The Dwarf Coconut in Malaya, H. W. Jack and W. N. Sands. Vol X. No. 1, 1922.

alluvial clay-loam with a high percentage of organic matter as shown by the following mechanical analysis, which was supplied by the Soils Division of the Department.

TABLE I.

MECHANICAL ANALYSES OF FOUR SOIL SAMPLES FROM PARIT BUNTAR OFFICE COMPOUND.

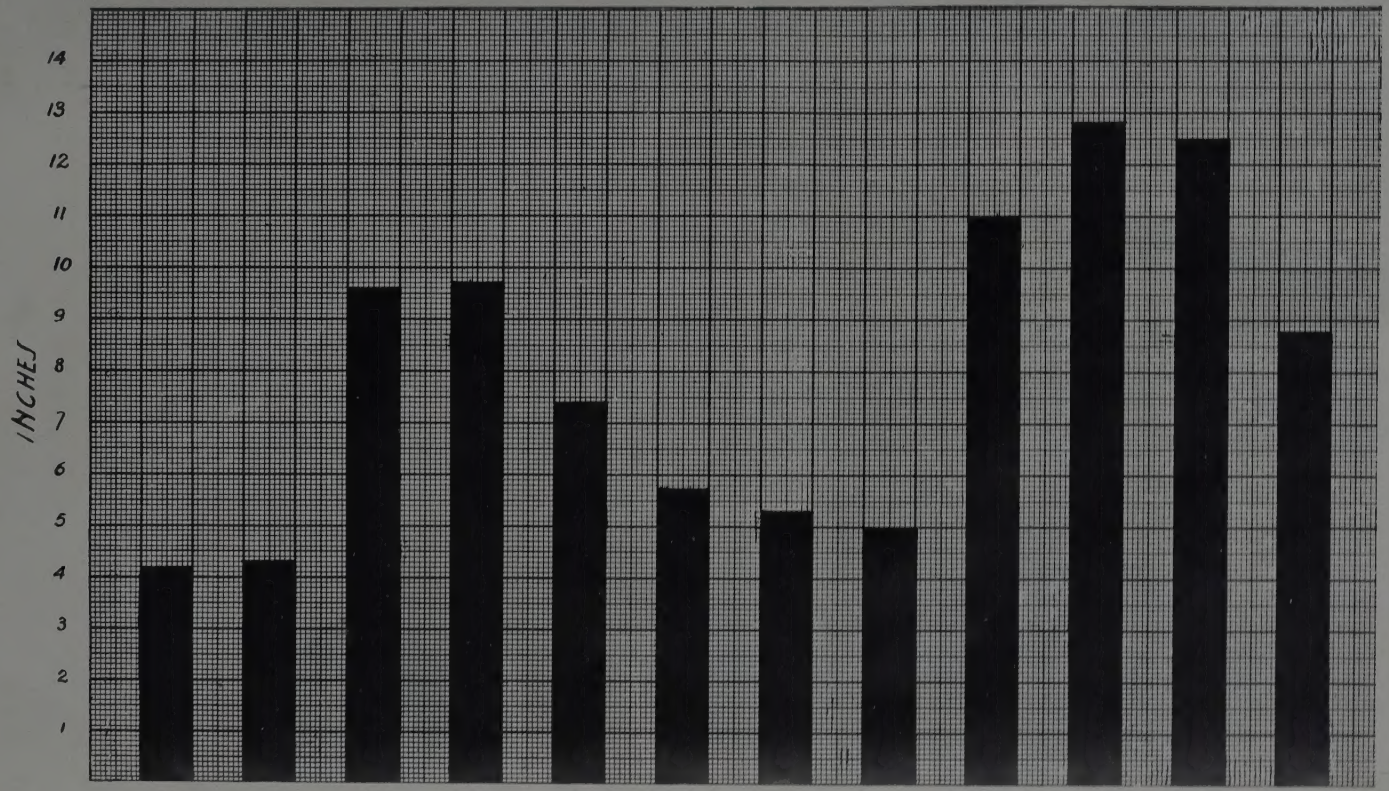
Ref:	Depth.	Clay & Fine Silt.	Silt.	Sand.	PH.	Remarks.
R 244 T	to 1 ft.	32	36	24	4. 7/6.0	All these soils were rich in organic matter, the average loss on ignition being 20%.
R 244 Sa	2 ft.	58	19	11	4. 5/4.6	
R 244 Sb	3 ft.	53	13	12	3. 1/3.2	
R 244 Sc	4 ft.	42	23	12	2. 8/3.2	

The permanent water-table is never more than 4 feet below the surface of the soil and generally averages about 2½ feet only.

The rainfall is usually well distributed and averaged 97.80 inches per annum for the years 1922-1928. This annual average was, however, 9.09 inches above that for the past 41 years—the last 4 years having been exceptionally wet. The average monthly rainfall for any one month during the period never fell below 4 inches, and the months of March and April and from September to November were, as a rule, the wettest periods. These conditions were fairly typical of the coastal areas where good crop of coconuts were obtained.

Table II shows the average monthly precipitation over the last seven years.

TABLE II.


INCHES
14
13
12
11
10
9
8
7
6
5
4
3
2
1
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC

Planting.

Six palms of each race were planted out in December 1921,of which five of each were selected for the purpose of our investigations: these have now been under close observation for the past seven years.

Germination to Flowering.

The nuts were sown on June 6th 1921. They germinated unevenly. The rates of germinations ranged in the 'yellows' from 35 to 79 days: the 'reds' from 21 to 92 days, and the 'greens' from 47 to 79 days. The date of germination assigned to each was that on which the tip of the young shoot became visible when busting its way through the husk. This variation in the rate of germination was expected as the nuts were not obtained, as far is known, from individual palms, so that there were, no doubt, differences in the ages of the fruits at the time of picking. On estates a period of four months from the time of sowing to germination is considered to be the limit for successful germination, so that these sprouted well within that time.

All of the palms were planted on December 11th, 1921, and subsequent growth was quite satisfactory. Among the 'yellows' and 'greens' the first to germinate was the first to flower, whilst of the 'reds', the third to germinate was the first to flower. From the time of planting to flowering nearly the same order was maintained.

The average period which elapsed from planting to flowering was for the 'yellows'—3 years, 86 days; the 'reds'—3 years, 105 days and the 'greens'—3 years, 263 days. The greens, however, flowered unevenly; the variation in the period between planting and flowering for the first time being considerable and included the earliest and the latest flowering palms of the whole series. Apparently they were not as pure, genetically, as the 'yellows' and 'reds'.

Table III shows the detailed results.

TABLE III.

No.	Race	Date Sown	Date Germinated	Difference in rates of germination	Date Planted	Date opening 1st spathe	Period from germination to 1st open spathe	Period from planting to 1st open spathe
1	Yellow	11.6.21	20.7.21	35 days to 79 days Av: 51 days	11.12.21	20.2.25	3 yrs. 215 days.	3 yrs. 71 days
2	,,	,,	29.8.21		,,	15.2.25	3 ,, 170 ,,	3 ,, 66 ,,
4	,,	,,	16.7.21		,,	7.3.25	3 ,, 234 ,,	3 ,, 86 ,,
5	,,	,,	30.7.21		,,	22.2.25	3 ,, 207 ,,	3 ,, 73 ,,
6	,,	,,	4.8.21		,,	30.3.25	3 ,, 238 ,,	3 ,, 109 ,,
1	Red	11.6.21	2.7.21	21 days to 92 days Av: 63 days.	11.12.21	29.4.25	3 ,, 301 ,,	3 ,, 139 ,,
2	,,	,,	7.8.21		,,	4.3.25	3 ,, 209 ,,	3 ,, 83 ,,
3	,,	,,	11.9.21		,,	14.5.25	3 ,, 245 ,,	3 ,, 154 ,,
5	,,	,,	29.8.21		,,	7.3.25	3 ,, 190 ,,	3 ,, 86 ,,
6	,,	,,	15.8.21		,,	15.2.25	3 ,, 184 ,,	3 ,, 66 ,,
1	Green	11.6.21	15.8.21	47 days to 79 days Av: 61 days	11.12.21	27.8.25	4 ,, 12 ,,	3 ,, 259 ,,
2	,,	,,	28.7.21		,,	20.9.24	3 ,, 54 ,,	2 ,, 282 ,,
3	,,	,,	6.8.21		,,	21.1.26	4 ,, 168 ,,	4 ,, 21 ,,
5	,,	,,	8.8.21		,,	16.4.26	4 ,, 251 ,,	4 ,, 126 ,,
6	,,	,,	29.8.21		,,	27.8.25	3 ,, 363 ,,	3 ,, 259 ,,

Spadix Production.

Spadix production was fairly well distributed throughout the seasons in each year: this was, no doubt, due to the fact that the water supply was ample for the requirements of the palms at all times. Each of the yellow and red palms started to flower in the early months of 1925. One green, however, commenced to flower in September, 1924, whilst two others did not flower until the early part of 1926. The 'yellows' produced on an average 18 spadices per annum: the 'reds' 15.5 only due to irregular spadix production of three of the palms in 1928. In this connection the cessation of spadix production for different periods in three of the red palms, although apparently quite healthy, is worthy of note. Red No. 2 was the most notable in this respect as it opened no spathes during two periods of 4 months and 5½ months respectively. The 'greens' produced 17 spadices per palm per annum the average being depressed somewhat by the late flowering of palm No. 4. The number of days between the opening of successive spathes varied for

(a) Yellows 18.5 days to 21.1 days.

(b) Reds 19.3 ,, ,, 24.2 ,,

(c) Greens 18.7 ,, ,, 23.1 ,,

The average for a normal dwarf race therefore being 20 days.

Early Spadices—Flowering and Fruiting.

The first spadix produced by dwarf palms bears few, if any, female flowers. In the palms under observation no female flowers were produced on the first spadix of the "yellows" and only two of them had female flowers on the second. The first spadices of the five palms set seven fruits only, five of which were borne on the 4th and 5th spadices of two palms. Two of the "reds" had 1 and 3 female flowers respectively, the rest none. No fruit was set on the first three spadices of these palms. Three of the "greens" bore female flowers on the 1st spadix, two of which formed fruits.

It might be mentioned that for all three types the number of branches per spadix, averaged 35. Also each spadix bends

TABLE IV.

RECORD OF SPADIX PRODUCTION FOR THE YEARS 1926, 1927 AND 1928.

		1926.		1927.		1928.	
No.	Race.	No. of spadices produced.	Average No. of days between successive spadices.	No. of spadices produced.	Average No. of days between successive spadices.	No. of spadices produced.	Average No. of days between successive spadices.
1	Yellow	17	20.8	18	20.5	18	19.8
2	,,	19	19.0	19	19.7	18	19.2
4	,,	19	19.7	18	20.6	18	20.1
5	,,	19	18.5	18	20.3	18	20.2
6	,,	18	19.9	17	20.6	17	21.1
1	Red	16	21.6	17	21.3	(c) 14	24.1
2	,,(a)	12	19.3	15	22.6	(d) 8	22.0
3	,,	16	22.5	15	20.5	18	19.4
5	,,	16	24.2	17	22.4	(e) 16	22.5
6	,,	17	21.7	18	19.5	17	20.6
1	Green	17	21.6	16	22.5	17	21.1
2	,,	18	20.3	18	20.0	18	20.6
3	,,	17	20.6	17	21.3	19	19.4
5	,,(b)	12	23.1	17	21.3	17	21.5
6	,,	17	21.3	18	20.0	19	18.7

(a) Record for 9 months only. Spadix production ceased from 3.10.26 to 12.2.27.

(b) Record for 8½ months only 1st spadix produced 16.4.26.

(c) No spadix 23.7.28 to 1.10.28.

(d) Record for 6½ months only. No spadix from 18.6.28. to [end of year.

(e) No spadix 11.6.28 to 24.7.28.

TABLE V.

Female Flowers and Fruit borne on 1st Five Spadices.

No.	Race.	Spadix 1 No. of F flowers.	*No. of nuts at 2 mnths.	Spadix 2 No. of F flowers.	No. of nuts at 2 mnths.	Spadix 3 No. of F flowers.	No. of nuts at 2 mnths.	Spadix 4 No. of F flowers.	No. of nuts at 2 mnths.	Spadix 5 No. of F flowers.	No. of nuts at 2 mths.	Total No. of F flowers on 1st 5 spadices.	Total No. of fruits set on 1st five spadices.
1	Yellow	0	0	0	0	3	0	5	0	8	0	16	0
2	,,	0	0	0	0	7	0	7	0	12	0	26	0
4	,,	0	0	4	0	4	0	7	1	9	1	24	2
5	,,	0	0	5	1	6	0	12	0	10	4	33	5
6	,,	0	0	0	0	2	0	0	0	2	0	4	0
1	Red	0	0	0	0	1	0	3	1	5	1	9	2
2	,,	1	0	7	0	8	0	6	2	13	4	37	6
3	,,	0	0	0	0	1	0	3	1	6	2	10	3
5	,,	3	0	0	0	2	0	7	0	7	5	19	5
6	,,	0	0	7	0	6	0	10	3	13	3	36	6
1	Green	0	0	2	0	5	2	8	1	7	2	22	5
2	,,	0	0	4	0	4	0	3	0	5	0	16	0
3	,,	5	4	11	3	15	0	15	0	25	11	71	18
5	,,	1	0	4	3	6	3	5	4	6	3	22	13
6	,,	6	3	0	0	8	0	10	0	11	2	35	5

*Number of fruits remaining on spadices 2 months after flowering.

TABLE VI.

Record of Annual Production of Flowers and Fruit, 1925—1929.

Race.		1st Year—1925-26					2nd Year—1926-27.			3rd Year—1927-28.				4th Year—1928-29.			
			Spadices 1925.	Female Flowers.	No. of nuts at 2 Months.	Crop 1926.	Spadices 1926.	Female Flowers.	No. of nuts at 2 Months.	Crop 1927.	Spadices 1927	Female Flowers.	No. of nuts at 2 Months.	Crop 1928.	Spadices 1928.	Female Flowers.	No. of nuts at 2 months.	Crop estimated 1929
Y.	1	20.2.25 to 31.12.25	17	187	62	51	17	286	81	72	18	265	125	104	18	236	100	83
,,	2	15.2.25 to 31.12.25	18	256	67	42	19	409	118	105	19	370	141	127	18	290	140	134
,,	4	7.3.25 to 31.12.25	12	65	21	18	19	297	131	101	18	285	117	105	18	153	60	50
,,	5	22.2.25 to 31.12.25	13	98	45	19	19	236	94	79	18	273	119	109	18	136	65	55
,,	6	30.3.25 to 31.12.25	13	39	9	8	18	305	121	101	17	274	110	104	17	207	96	89
R.	1	29.4.25 to 31.12.25	9	18	6	2	16	155	57	56	17	305	121	104	14	161	65	65
,,	2	4.3.25 to 31.12.25	13	163	56	46	12	192	72	60	15	225	116	107	8	139	37	34
,,	3	14.3.25 to 31.12.25	10	43	17	8	16	273	99	97	15	176	76	72	18	285	131	123
,,	5	7.3.25 to 31.12.25	10	52	23	17	16	221	99	87	17	239	103	91	16	275	132	125
,,	6	15.2.25 to 31.12.25	15	232	55	46	17	350	116	111	18	247	134	112	17	311	114	101
G.	1	27.8.25 to 31.12.25	7	42	12	12	17	447	88	74	16	384	120	89	17	411	93	88
,,	2	3.1.25 (i) to 31.12.25	16	320	83	48	18	412	86	74	18	370	102	84	18	350	95	85
,,	3	No flowers	0	...	...	...	*17	369	97	72	17	408	117	90	19	510	137	123
,,	5	do	0	...	...	...	†12	70	47	45	17	376	157	143	17	394	146	133
,,	6	27.8.25 to 31.12.25	8	64	9	6	17	467	88	73	18	414	73	68	19	453	105	83

(i) Produced 4 spadices with 11 flowers in 1924.

* Commenced flowering 21.1.26.

† Commenced flowering 16.4.26.

down in a direction opposite to that of the spiral formed by the expanding leaves, and all the spadices of each palm bend downwards in the same direction.

The details of flower and fruit production of the first five spadices of each palm are given in Table V, and the details of spadix, flower, and fruit production from commencement of flowering of each palm to the beginning of 1929 are given in Table VI.

The very uneven nature of the early flowering and fruiting of the palms particularly the "greens", is very noticeable. In the second year of fruiting they produce almost an average crop, and appear to reach full production about the third year. As the records are for a four year period only and for a small number of palms, it may be necessary to alter this statement when further annual records are obtained.

Table VII, compiled from Table VI, gives the total female flower and fruit production of each palm to the end of 1928, and Table VIII shows the averages. Among the points to be noted are—

(a) The 'greens' had the highest average number of female flower per spadix, namely 21.4: the 'yellows' had 13.6 and the 'reds' 10.6.

(b) The high percentage of female flowers which fail to set fruit.

(c) The low percentage of loss of fruit after 2 months from the time of flowering.

In regard to (b) and (c) the percentage of fruits to flowers remaining at 2 months, was for the 'yellows' 38.90%; 'reds', 53.2% and 'greens' 26.4%. Subsequent losses of fruit amounted to 5.7%, 5.4% and 4.2% only respectively.

The high percentage of infertile flowers was not due to insect injury, but, rather, it is thought to imperfect pollination or absence of viable pollen in unfavourable weather. On the other hand it is possible that the failure of development of a certain number of young fruits may be physiological.

TABLE VII.

RECORD OF TOTAL FLOWER AND FRUIT PRODUCTION OF DWARF COCONUT PALMS FROM THE TIME OF 1ST FLOWERING TO FEB. 28TH, 1929.

Race.	Palm No.	Total No. of Spadices.	Total No. of Female Flowers.	Total No. of Nuts at two Months.	Total No. Fruits which matured*	Remarks.
Yellow	1	69	974	368	310	
,,	2	74	1325	466	408	
,,	4	66	800	329	274	
,,	5	68	748	323	262	
,,	6	67	825	336	299	
Red	1	56	639	249	227	No spadix from 23.7.28 to 1.10.28
,,	2	48	719	281	247	No spadix from 3.10.26 to 12.2.27 do. 18.6.28 to 2.1.29
,,	3	59	777	323	300	
,,	5	59	787	357	320	No spadix from 11.6.28to 24.7.28
,,	6	67	1140	419	370	
Green	1	57	1284	313	263	
,,	2	74	1452	366	291	
,,	3	53	1287	351	285	Started to flower 21.1.26
,,	5	46	840	350	321	Started to flower 16.4.26
,,	6	62	1398	275	230	
		925	13995	5106	4407	

* The 1929 crop was estimated on 28th February 1929 from the number of fruits then two months old and over on the spadices produced in 1928.

TABLE VIII.

Summary from Table VII.

Race	No. of palms	Totals of spadices	Totals of female flowers	Totals of fruits at 2 months	Totals of mature fruits
Yellow -	5	344	4,672	1,822	1,553
Red -	5	289	3,062	1,629	1,464
Green -	5	292	6,261	1,655	1,390
		925	13,995	5,106	4,407

Averages per Palm.

Race	Spadices.	Female flowers per spadix	Female flowers per palm.	Fruits 2 months	Mature fruits	Mature fruits per spadix
Yellow -	69	13.6	946	364	311	4.5
Red -	58	10.6	612	326	293	5.0
Green -	58	21.4	1,252	331	278	4.8

Percentages—Fruits to Female Flowers.

Race	Total female flowers	Fruits at two months %	Fruits at maturity %	Loss of fruits 2 months to maturity %
Yellow -	4,672	38.9	33.2	5.7
Red -	3,062	53.2	47.8	5.4
Green -	6,261	26.4	22.2	4.2

Fruit Production for 3 Years, 1926—1928.

The total numbers of ripe fruits obtained from the young palms over the period of three years, 1926—1928, are given below. The 'yellows' are shown to have given an average annual production of 94.5 fruits. The 'reds' 89.6 and the 'greens' 88.2. The average production of the 'reds' and the 'greens' was depressed by the erratic spadix production of R.2 in 1928 and the late flowering of G.5, although the latter was the heaviest cropper, notwithstanding its late start. As mentioned previously, full production may not have been reached in the period under review.

TABLE IX.

Fruit Production for 3 Years of Dwarf Palms. Planted Dec. 21st, 1921.

No.	Race.	1927 Total Fruit.	1928 Total Fruit.	1929 Total Fruit calculated from 2 months or over.	Grand Total.	Remarks.
1	Yellow	72	104	83	259	
2	,,	105	127	134	366	
4	,,	101	105	50	256	
5	,,	79	109	55	243	
6	,,	101	104	89	294	
1	Red	56	104	65	225	No spadix 23.7.28 to 1.10.28
2	,,	60	107	34	201	No spadix 3.10.26 to 12.2.27. 18.6.28 to 31.12.28.
3	,,	97	72	123	292	
5	,,	87	91	125	303	No spadix 11.6.28 to 2.7.28.
6	,,	111	112	101	324	
1	Green	74	89	88	251	Started to flower 21.1.26.
2	,,	74	84	85	243	
3	,,	72	90	123	285	
5	,,	45 ($8\frac{1}{2}$ mths. only)	143	133	321	Started to flower 16.4.26.
6	,,	73	68	83	224	
Totals		1,207	1,509	1,371	4,087	

AVERAGE PRODUCTION.

Race.	1927.	1928.	1929.	Annual average of 3 years.
Yellow	91.6	109.8	82.2	94.5
Red	82.2	97.2	89.6	89.6
Green	67.6	94.8	102.4	88.2
Mixed	80.5	100.6	91.4	91.27

MATURATION PERIOD OF THE FRUIT.

It is not possible to ascertain definitely by external appearances when a fruit has reached, and not passed, the stage at which it is fully mature, so that the exact time from flowering to ripening can only be estimated. The fruits of all of the palms were picked when the husks had lost all of their distinctive colour and were quite brown and dry.

The Table X shows that, from the flowering to the date the fruits were picked, the period which elapsed was for the 'yellows' 12.4 months; 'reds' 13.4 months and 'greens' 13.1 months. The yellow fruits, therefore appear to reach maturity about one month earlier than the others. In this connection it is possible that the fruits may have reached maturity 3—4 weeks earlier than indicated by the periods above (flowering to picking).

TABLE X.

Maturation Period of Fruit in Months.

Race.	Palm No.	Fruits picked in 1926.	Fruits picked in 1927.	Remarks.
Yellow	1	12 months.	12 months.	Early ripening
,,	2	12.2	12.4	
,,	4	12.3	12.6	
,,	5	12.4	13.	
,,	6	12.3	12.8	
	average	12.2	12.5	
Red	1	12.6	12.8	Early ripening.
,,	2	13.4	13.1	
,,	3	13.3	13.8	
,,	5	13.5	13.7	
,,	6	14.1	13.6	
	average	13.4	13.4	
Green	1	13.4	13.3	
,,	2	13.3	13.2	
,,	3	13.2	13.3	
,,	5	12.0	12.8	Early ripening.
,,	6	13.4	13.0	
	average	13.1	13.1	

Pollination of the Flowers.

In our former article (loc. cit.) we stated that flowers were usually self-pollinated owing to the fact that the male and female phases of flowering of each spadix produced by these races of dwarf palms overlapped each other. Although numerous insects; more particularly bees, visit the male flowers to collect pollen and nectar, few appeared to be attracted by the female flowers situated near to the bases of the branchlets of the inflorescence, and following the results of experiments the opinion was expressed that pollination was effected chiefly by the wind.

As yet there is no detailed survey of the insect visitors to the flowers and the rôle they may play in scattering pollen

or facilitating self-pollination in other ways. Aldaba (2) showed that in the Philippines the amount of pollen carried by the wind, from cluster to cluster on the same tree, was probably enough to pollinate the female flowers of tall palms when the male phase of the flowering spadix overlapped the female phase of the previous spadix. As this could occur between different spadices on the same tree, it could be accomplished far more readily on a palm where there was an ample supply of pollen available on the same spadix.

Results of Germinating the Fruits.

The three races of dwarf palms are growing in three lines along three sides of the compound of the office at Parit Buntar. They are separated from each other in the lines at distances of 20 feet to 30 feet only, so that, if any appreciable amount of cross-pollination due to wind or insects occurred, it would be noticeable in their progeny.

A number of fruits of each was, therefore, collected and germinated and certain of them planted out at the Coconut Experiment Station, Klang.

The germination results of this second generation of nuts, totalling 642, showed that, in respect to the colour of the young shoot and subsequent growth, they were apparently true to the type of palm from which they were taken, with three exceptions which all occurred amongst the "greens". G.1 gave two red plants and G.6 one red plant. This was thought to be due to a mistake in labelling because the character for green plants is likely to be dominant to red—still cross-pollination was possible.

Twenty five plants from each palm were planted out from the germination beds and these are now nearing the flowering stage. To date no characters suggesting hybridization in this planting have been observed.

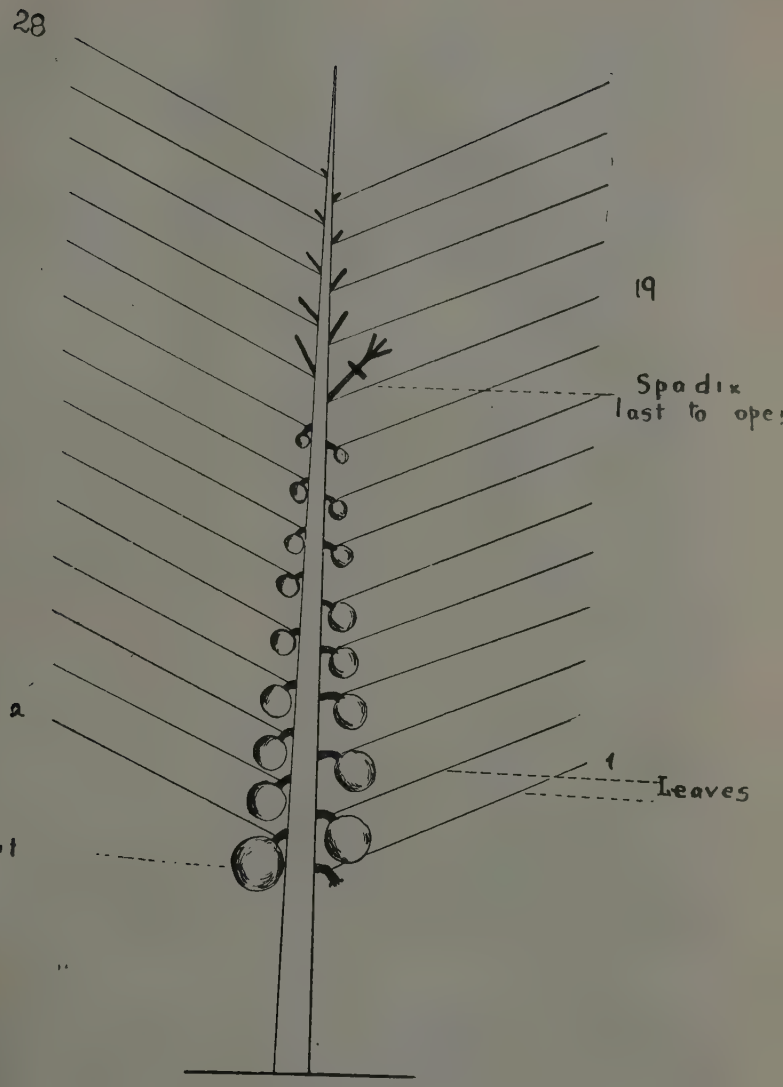
---

(2) Aldaba V.V.—Philippine Agriculturist, Dec. 1921. No. 5.

TABLE XI.

GERMINATION RESULTS OF FRUIT FROM INDIVIDUAL PALMS.

Race.	Palm No.	No. of fruits germinated.	Colour of shoot on germination.	Race.	Palm No.	No. of fruits germinated.	Colour of shoot on germination.	Race.	Palm No.	No. of fruits germinated.	Colour of shoot on germination.
Yellow	1	26	Yellow	Red	1	67	Red	Green	1	53	(51 green) (2 red.)
do	2	40	,,	do	2	30	,,	do	2	55	Green
do	4	45	,,	do	4	32	,,	do	3	47	,,
do	5	35	,,	do	5	58	,,	do	5	24	,,
do	6	40	,,	do	6	36	,,	do	6	54	(53 green) (1 red)
Total		186		Total		223		Total		233	



DIAGRAMMATIC SKETCH OF A
DWARF PALM IN BEARING

Leaves and Leaf Production.

The number of fully opened leaves of all ages, which forms the crown, may vary from 24 to 28 in palms up to seven years old. As a rule there are from 8 to 10 expanded leaves above a spathe which has newly opened.

As a spathe with its spadix is produced, normally, in the axil of each leaf once flowering starts, the rate of leaf-production can be calculated from the rate of opening of successive spathes. As one spathe follows another at intervals of about three weeks, 17 to 19 are produced each year, which number would also be the number of leaves which unfolded during that time.

A leaf may not fall for some weeks after the fruit on its spadix has ripened so that the time which elapses from unfolding to shedding varies but is approximately eighteen months. Should, however, disease attack the base of the stalk, it may fall earlier.

From the data which has now been given it is possible to make a diagrammatic sketch (see previous page) of a dwarf palm in bearing.

Crops.

During the past 7 or 8 years various estimates of crop returns from dwarf palms have given from 16 to 25 pikuls of copra per acre per annum as a fair yield for palms in full bearing under good average conditions. Few dwarf palm areas have yet reached the full producing stage, but it may be mentioned that one estate has recorded a yield of 19.29 pikuls of copra per acre from 100 acres of palms in their eighth year. This is the highest crop yet recorded for dwarf palms though other estates are obtaining crops approaching that figure, which has only rarely been touched by mature palms of the tall variety.

The fifteen dwarf palms, from which most of the data used in these "observations" are derived, have averaged 80.5, 100.6 and 91.4 fruits per annum in their 5th, 6th and 7th years respectively, from planting under good conditions though the soil in which they stand is distinctly heavy.

This rate of production of fruit gives an average per annum from 5th year from planting of 91 fruits per palm, and there seems to be no reason why this average should not be maintained and even improved. These palms are not growing under ordinary estate conditions, being subjected to rather

more shade from adjacent trees and hedges, but their average yield of fruits would give a calculated yield of some 15 pikuls of copra per acre from 5 year old palms which is undoubtedly useful compared with talls of the same age or even older.

Under ordinary estate conditions where 90—108 palms are planted to the acre, the commercial aspect of dwarf palms can be gauged from the average figures in Table XII, which are derived from actual returns collected from six estates and represent over 1,300 acres of dwarf palms.

TABLE XII.

PRODUCTION OF DWARFS AND TALLS COMPARED. THE FIGURES FOR DWARFS ARE AVERAGED FROM 6 ESTATES.

	Dwarfs.	Talls.
No. of palms planted per acre	90	48-55
Crop in pikuls of copra per acre 4th year	2.29	0
" " " " " " " 5th "	6.19	.5
" " " " " " " 6th "	7.52	2.00
" " " " " " " 7th "	9.24	4.00
" " " " " " " 8th "	11.68	6.00
From 10th year (estimated)	13.00	8.73
No. of nuts per pikul of copra (mainly yellow)	560	251
ditto - average of two estates (mixed dwarf palms)	482	251
ditto - green race only - estimated.	430	251
Weight in grammes of copra per nut (to nearest 10 grms.)	130	260
No. of nuts per palm per annum (conditions favourable)	90	56
Production of copra in lbs. per palm per annum (favourable conditions)	25	32
Production of copra per acre per annum in lbs. (favourable conditions)	2250	1600

From the above Table it can be seen that in addition to early maturity of the dwarf palms, they produce, under favourable conditions, some 25 lbs. of copra per palm per annum as compared with 32 lbs. from "talls". Hence, the advantage of dwarf palms over "talls" is that 90 palms can be planted to the acre as against only 50 "tall" palms and since 64 dwarf palms ($64 \times 25 = 1,600$ lbs.) can produce as much copra as 50 'talls', the production of the remaining 26 dwarf palms per acre is roughly a measure of the higher returns per acre of which dwarfs are capable compared with "talls" at the present time.

In collecting the above figures one estate had planted 108 palms to the acre, but all the others carried only ninety palms. As these figures are averages it must be understood therefore, that where conditions are good higher yields will be obtained, and conversely, uncongenial conditions or lack of attention will result in poorer crops. Thus, on the estates included in the above averages the production from 'dwarfs' in the eighth year ranged from 8.72 pikuls per acre to 19.29 pikuls. Dwarf palms are mature three or four years earlier than ordinary tall palms, and they produce profitable crops from their fifth year onwards as shown in Table XII.

In four out of the six estates the yellow type of dwarf was cultivated almost exclusively and hence the high figure for the number of nuts required to produce one pikul of copra. Two of the estates carried mixed populations of red, green and yellow palms and from these two estates 482 nuts only were required to make one pikul of copra. The dwarf plantations under observation are not yet mature enough to supply production figures beyond the 8-9th year from planting so that the average yield of 13.00 pikuls of copra per acre for mature dwarfs is estimated. Against this 8.734 pikuls of copra is quoted as the average production from tall palms and this was the actual average derived from figures collected from 30 well known estates, though for favourably situated estates the average exceeds 9.00 pikuls. The price obtained by estates for copra derived from dwarf palms does not differ materially from that paid for copra from tall palms, in fact most estates do not even separate them in preparing consignments for sale.

On most areas on which dwarf palms are planted the yellow type predominates excessively, being popular on account of its bright appearance. This fact is to be regretted since,

although it may yield a few more fruits per palm in its early years as is indicated in Table IX, it is now known that the yellow type on the average produces a smaller fruit yielding less copra per nut than either the red or the green type as shown in Table XIII. Moreover, the yellow type produces meat which appears to be more difficult to cure compared with that from the red and green types. Possibly high sugar content may account for this difficulty for the meat and the milk of the yellow dwarf are said to be sweeter than those from other dwarf types or than "talls".

Furthermore, the yellow type appears to be more readily subject to pest attacks and less resistant to poor conditions generally, than either the green or the red type. The green type is undoubtedly the hardiest as was anticipated several years ago on theoretical grounds.

TABLE XIII.

ESTATE PRODUCTION—THE NUMBER OF NUTS REQUIRED TO PRODUCE 1 PIKUL (133 LBS.) OF COPRA.

Race.	Estate.	No. of nuts.	Copra in pikuls.	No. of nuts per pikul.
Green	A	1,500	4.115	462
,,	B	500	1.035	483
,,	C	1,422	3.760	405
	Totals	3,422	8.910	Average = 407
Red	A	996	2.225	448
,,	B	100	.20	500
,,	C	120	.26	461
	Totals	1,216	2.685	Average = 453
Yellow	A	1,482	3.040	488
,,	B	1,000	1.760	568
,,	C	1,493	3.028	493
	Totals	3,975	7.828	Average = 508

The figures in the above Table were supplied by three estates A, B, and C which, at the request of the writers, kindly carried out carefully supervised tests of the Comparative amounts of copra obtainable from nuts of the three different colour types.

The Table shows that the number of nuts required to produce 1 pikul of copra for the green type averaged 407 nuts, for the red type 453 nuts and for the yellow type, 508 nuts. These figures would probably be increased by 5% in each case under ordinary estate routine as they are derived from an insufficiently large number of nuts to ensure accuracy, but they definitely indicate the approximate proportions which exist between the three colour types as copra producers. The figures also show that the average sizes of the nuts of each type vary considerably on the three estates; this is, no doubt, mainly due to varying environmental conditions and to different degrees of cultivation.

At the same time it must be mentioned that inherent variation in size of nuts is marked. Thus dwarf palm E.B. No. 139 (Green 3) has consistently produced nuts some 20% larger than those of any of the other palms under observation by the writers. The result of an examination of bulked samples of small numbers of nuts collected from various sources is shown in Table XIV. The figures in this Table, though only derived from a very small number of nuts and therefore subject to a wide margin of error (probably not less than 10%) roughly confirm the proportionate copra producing abilities already indicated in Table XIII.

Thus, for the green type the average weight of copra produced per nut was found to be 143 grammes, for the red type 139 grammes and for the yellow type 129 grammes, and by calculation these figures would give 422, 434 and 468 nuts respectively to one pikul of copra for green, red and yellow types.

TABLE XIV.

Analyses of Dwarf Fruits.

Race.	Average weight in grammes per nut.			% Moisture in copra.	% Oil on dry basis.
	Nut	Meat	Copra		
Green Lot A – 11 nuts	480	248	134	9.01	65.78
„ „ B – 12 „	510	231	131	6.70	64.32
„ „ C – 20 „	560	253	135	—	—
„ „ D – 20 „	710	337	162	—	—
Averages	584	243	143	7.80	65.02
Red Lot A – 11 nuts	620	275	140	8.31	64.10
„ „ B – 9 „	460	236	136	8.54	68 88
„ „ C – 24 „	550	260	134	8.34	65.69
„ „ D – 19 „	640	278	148	—	—
Averages	557	243	139	8.37	65.94
Yellow Lot A – 12 nuts	420	201	123	10.01	64.91
„ „ B – 12 „	590	252	126	8.61	66.22
„ „ C – 24 „	470	231	120	—	—
„ „ D – 22 „	550	280	143	5.95	63.70
Averages	511	245	129	7.74	64.78

Table XIV also shows the average moisture content of the various copra samples and the oil content expressed as a percentage of the dry weight of copra. The average oil content percentages of the three races are approximately the same and coincide with the average oil content of copra derived from the ordinary tall varieties of palms which fluctuates normally from 64—66% in this country.

In the Table, the "D" lots all came from the same source and it is noticeable that these samples in each case show a higher copra content per nut than the other lots in each class. This is probably due to better environmental condi-

tions, particularly as regards soil, and shows how improved conditions tend to produce larger nuts. The moisture and oil percentages were determined by officers of the Chemical Division of the Department of Agriculture to whom the writers are indebted.

Economic Life of the Dwarf Palms.

Doubt is sometimes expressed regarding the length of the economic life of dwarf palms as compared with the ordinary tall types and it has often been assumed that it is limited to 17—20 years. This supposition is based on statements made by Banjarese cultivators who have been accustomed to grow the dwarf palms in the Krian District of Perak State where for 9 months every year the land is inundated for padi cultivation and even in the brief dry spells of weather between the padi season the water table never drops more than two feet below the surface of the soil. Dwarf palms at least 35 years old and still bearing quite good crops can be seen as isolated trees, usually planted for ornamental purposes, in various parts of the country and though no plantations of dwarfs of sufficient age exist to guide opinion there seems no reason why they should not produce profitably for at least 35 years under good estate management. Observations have idicated that where general conditions for growth are good, the dwarf palm gives excellent returns but where conditions are only fair or rather difficult, they are not so satisfactory. The green type, as has been shown, produces the best individual fruits from the viewpoint of copra production and approximately equals the other dwarf types in the number of fruits matured annually.

The green dwarf, under fair average conditions, is capable of producing some 25 lbs. of copra per palm per annum which is nearly as much as the average tall palm produces, (about 27-28 lbs.), whereas double the number of dwarf palms can be planted per acre of land hence the green dwarf should prove a lucrative investment.

Other Advantages of Planting Pure Races of Dwarf Coconuts.

The planting of pure races of early fruiting dwarf coconuts which grew and yielded well under local conditions

offers certain advantages over the tall forms at the present time, among these being—

(a) Similar growth and fruiting characters.
(b) Each palm is genetically a high-yielder.
(c) The palms mature evenly.
(d) The probable production of copra of less variable quality.

The above remarks would apply equally well to the tall types, but as far as is known there is none as pure genetically as the local dwarfs we have described, with the result that in all plantations there are bad, medium and good yielding palms.

In our paper (3) on variation in tall coconuts we have shown (a) that the co-efficient of variability in fruit production is as much as 37% of the mean production, (b) that 19% of the palms on an average estate are not profitable, (c) that 13% of the average population produces 22% of the crop and (d) that high-yielders remain high-yielders and poor-yielders remain poor-yielders.

Many of the tall palms we have studied have produced an average of 85 nuts and over per annum (records cover a period of eight years) so that apart from the question of early maturity of the dwarfs, if tall forms could be obtained, which would breed true, as the dwarfs do, to the character or characters for high yield, then these would prove superior to the dwarfs in yield of copra per acre, and perhaps in other ways.

This aspect of coconut production is being dealt with by the Botanical Division of the Department in the Coconut Experiment Station where breeding experiments with both tall and dwarf races are in progress.

Toddy from Dwarf Palms.

Dwarf palms would appear to be useful from the view point of "toddy" production since the young palms usually flower 3-4 or even more years earlier than tall palms and approximately twice as many palms can be planted to the

(3) Variation in Coconuts. H. W. Jack and W. N. Sands. Malayan Agricultural Journal. Vol. XV. No. 11 (1927).

acre. Moreover, the spadices of dwarf palms are produced in more rapid succession and are more easily accessible than those of 'talls' though more spadices have to be tapped to produce the same amount of liquid as compared with tall palms. Tamil coolies prefer "toddy" derived from dwarf palms because it is sweeter and more palatable than that produced by talls.

The yield of toddy per day from young 'dwarfs' varies from half a pint up to about six pints, but a fair average yield per palm would be about one and a half pints daily. Tall palms would average about double this quantity, but the rate of collection would be slower and more arduous. The chief factors in favour of dwarf palms in this connection are the ease of collection of liquid, the earlier returns as compared with tall palms, and the popularity of the liquid on account of its sweetness.

Summary.

1. The germination, growth, flowering and fruiting characters of the three common races of dwarf palms are described.

2. The cropping abilities of the 'dwarfs' are shown in detail for 15 palms which have been under strict observation since germination.

3. Crop returns from dwarf areas of six commercial estates are averaged and compared with average returns from commercial areas of "talls".

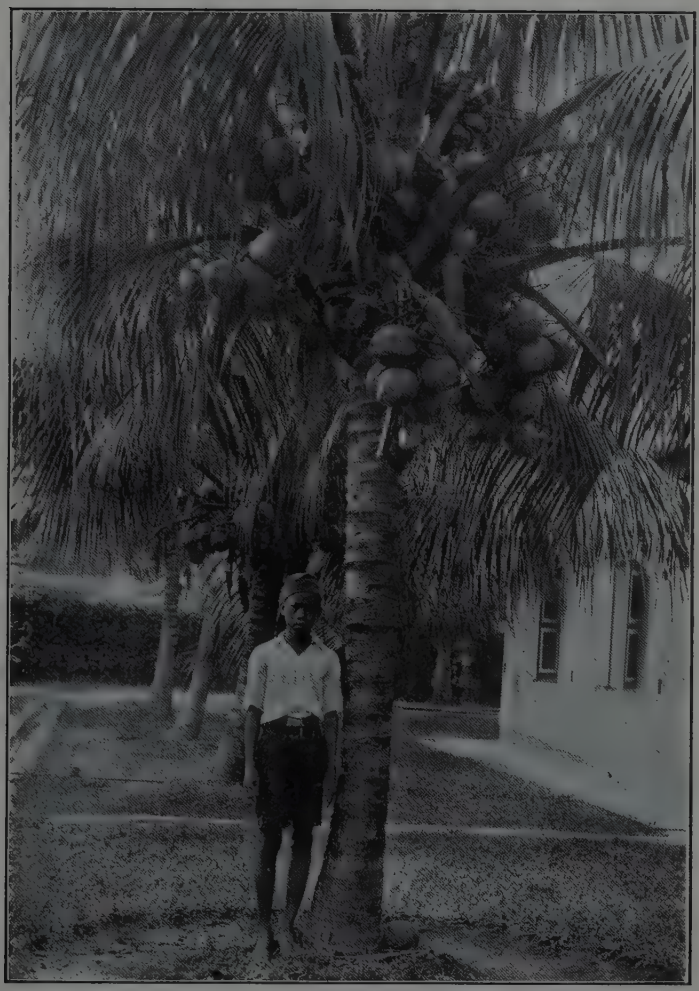
4. Variation in average copra producing ability between the three common dwarf types is outlined.

5. It is shown that, given suitable conditions and fair treatment, the dwarf palm (particularly the green race) is a sound commercial proposition.

Received for publication 9th April, 1927.

Dwarf Yellow—4 years old.

Dwarf Red—4 years old.



Dwarf Red—7 years old.

Dwarf Green—4 years old.

Dwarf Green—7 years old.

Piqui-a Fruit Oils.

C. D. V. Georgi,
Ag. Agricultural Chemist.

Introductory.

Piqui-a, *Caryocar villosum*, a large tree indigenous to Brazil is a comparatively recent introduction to Malaya, the first seeds having been imported about nine years ago for planting under estate conditions.

The trees have made good growth, being now about 50 feet high and with a spread of branches approximately equal to the height.

The trees flower between the months of March and June, the fruits ripening during October and November.

Piqui-a fruit, like oil palm fruit, contains two oils, one present in the pericarp of the seed, the other in the kernel.

Description of Fruit.

The sub-drupaceous fruits, which may contain as many as three or four seeds, are globular in shape, measure 4—4½ inches in cross section and approximate in size to large oranges. When there are two or more seeds present the fruit tends to assume an oblong shape. The outer layer of the pericarp, which is approximately ½ inch in thickness, is light brown in colour and smooth in texture.

It is interesting to note that this outer layer contains a relatively high percentage of a tannin of a pyrogallol type, amounting to approximately 9.0 per cent on the fresh material, equivalent to 33 per cent on a moisture-free basis.

The seeds, which vary from 2¼ to 2½ inches in length, are flattened at the base and rounded at the apex. The inner layer of the pericarp surrounding each seed and approximately ⅛—¼ inch thick is yellow in colour and contains oil. The material composing this layer darkens on exposure to air.

The shell of the nut varies in thickness from approximately $\frac{1}{4}$ inch on the sides to $\frac{1}{2}$ an inch at the apex, the shell itself being composed of two layers, an outer layer full of brittle spicules and a hard thin inner layer.

The kernel is about 2 inches long and $\frac{3}{4}$ inch thick and is covered with a dark brown testa. The flesh of the kernel is white.

Composition of Fruit.

The following table shows the approximate composition of the fresh fruit, the inner layer of pericarp and the kernel:—

Fresh fruit.

Average weight of fruit.	300 grammes. per cent.
Proportion of outer layer of pericarp ...	73.9
Proportion of inner layer of pericarp ...	13.1
Proportion of shell ...	11.3
Proportion of fresh kernel ...	1.7
Proportion of pericarp oil on fresh fruit	6.2
Proportion of kernel oil on fresh fruit ...	0.8

Inner layer of pericarp.

Moisture ...	34.4
Oil (petroleum ether extract) ...	47.4
Residue (by difference) ...	18.2
Oil (calculated on moisture-free basis) ...	72.3

Kernel.

Moisture ...	26.6
Oil (chloroform extract) ...	45.1
Residue (by difference) ...	28.3
Oil (calculated on moisture-free basis) ...	61.4

Characteristics of Oils.

Owing to the small number of fruits available it was not possible to prepare sufficient quantities of either of the oils

for the determination of the more important analytical constants by treating the material in the small laboratory hand-press. Both the pericarp and kernels were therefore solvent extracted, the former with petroleum ether and the latter with chloroform.

The pericarp oil is reddish-orange in colour and has an agreeable odour. When cooled a few degrees below the normal atmospheric temperature the oil solidifies to a fat which is somewhat lighter in colour.

The kernel oil is yellowish in colour and semi-solid at ordinary temperature. The oil is odourless when cold, but develops a slightly unpleasant odour on heating.

The table on page 169 gives the details of the physical and chemical characteristics of the oils, average figures for palm oil being added for comparison with those for the pericarp oil. Figures showing the constants of an oil from another species of *Caryocar*, referred to in "Chemical Technology and Analysis of Oils, Fats and Waxes", Lewkowitsch and Warburton, Vol. II, page 567 are also added for comparison with those for the kernel oil. No figures appear to have been published previously for any pericarp oil from a *Caryocar* species.

It is interesting to note that this oil from *Caryocar tomentosum*, known as Sawarri or Souari fat, is sometimes referred to as "Pekeanut" oil and as regards its constants they will be seen to be similar to those for the kernel oil from the present species under examination.

Remarks and Conclusions.

The results of analysis show that the constants of the pericarp oil agree closely with those for palm oil and it appears probable therefore that piqui-a pericarp oil can be used for similar purposes. The oil is easily bleached and high quality oil would therefore be suitable as a basis in the preparation of edible fats.

A series of experiments showed however that in the preparation of high quality oil it would be necessary to treat the ripe fruits without delay owing to the presence of an enzyme causing free fatty acids to develop on storage.

TABLE SHOWING CHARACTERISTICS OF PIQUI-A FRUIT OILS.

	Piqui-a fruit pericarp oil.	Palm oil.	Piqui-a fruit kernel oil.	Oil from *Caryocar tomentosum.*
Specific gravity at 99°C (water at 15°C = 1) ...	0.8622	0.859	0.8617	0.8981[1].
Melting point (complete fusion)	27°-28°C	27°-42.5°C (varies according to acidity)	31°-32°C	29.5°-35.5°C
Saponification value ...	204.9	199-201	202.9	199.51
Iodine value (Wijs) ...	46.6	53-58	52	49.5
Acidity (Oleic acid per cent) ...	1.1		0.2	
Unsaponifiable (per cent) ...	0.7		1.3	
Fatty Acids.				
Solidifying point (Titer value)	48°C	40°-47°C		46°-47°C
Mean molecular weight ...	274	273		272.8
Iodine value (Wijs) ...	48.5	53		51.5

[1] Specific gravity at 40°C

The kernel oil, similar to the oil from *Caryocar tomentosun*, could also be used for edible purposes. In this connection it is interesting to note that the kernels of this species and the allied species, *Caryocar nuciferum*, are highly esteemed as dessert nuts in West Indies and South America.

In conclusion the writer desires to express his thanks to the Directors of the Irai Co., Ltd., for permission to publish the results of the investigation.

Received for publication 20th April, 1929.

Oil from Hydnocarpus Anthelmintica.

C. D. V. Georgi,
Ag. Agricultural Chemist
and
Gunn Lay Teik,
Assistant Analyst.

Introductory.

A consignment of fresh seeds of *Hydnocarpus anthelmintica*, Pierre was received recently from the Government Experimental Plantation, Serdang where this tree is being cultivated.

As is well known the question of the cultivation of this tree has attracted much attention recently on account of the application which the oil from the seeds finds in the treatment of leprosy.

A full description regarding the introduction of *Hydnocarpus anthelmintica* to Malaya, its habit of growth under local conditions and the methods of cultivation employed at Serdang has already been published in this Journal, compare "Chaulmoogra and Hydnocarpus Oils", Vol. XV, 1927 No. 4, page 114, the article being based on information published during the previous year in the Bulletin of Miscellaneous Information issued by the Royal Botanic Gardens, Kew.

In this connection it may be mentioned that both *Hydnocarpus Wightiana*, Blume and *Taraktogenos Kurzii*, the seeds from which yield oils similar to that from *Hydnocarpus anthelmintica*, are also under cultivation at Serdang.

From a chemical point of view the fatty acids present in the greater proportions in these oils, namely chaulmoogric and hydnocarpic acids, are unique among naturally-occuring fatty acids on account of their cyclic structure and optical activity.

Further, since from a medical point of view better results have been obtained in certain cases with preparations containing hydnocarpic acid derivatives it is essential to determine as early as possible whether this acid is present in the oil from the *H. anthelmintica* now under cultivation at Serdang. Such an investigation will, however, only be possible when larger supplies of the seed are available.

Although the amount of seed available was insufficient to permit of a detailed examination of the fatty acids it is considered advisable to publish the preliminary results in view of the world-wide interest now being taken as regards both chaulmoogra and hydnocarpus oils as a cure for leprosy.

Oil Content of Seed.

The seeds were brown in colour, $\frac{3}{4}$ - 1 inch long and $\frac{1}{2}$ - $\frac{3}{4}$ inch broad. A hard shell encloses the kernel, which is covered with a thin reddish-brown skin. The flesh of the kernel is white.

The results of analysis are shown in the following table.

Seed.	grammes.
Average weight of seed	... 2.42
Average weight of kernel	... 0.77
	per cent.
Proportion of shell	... 68.2
Proportion of kernel	... 31.8
Kernel.	
Moisture (loss at 100°C)	... 26.5
Oil (petroleum ether extract)	... 42.5
Residue (by difference)	... 31.0
Oil (calculated on moisture-free basis)	... 57.8
Oil (calculated on fresh seed)	... 13.5

Analytical Constants of Oil.

The kernels were crushed by passing between rollers, but owing to the moist state of the kernels it was necessary to dry

the resultant meal before pressing in the small laboratory hand-press. No difficulty was experienced as regards the expression of the oil. The crude oil was filtered to remove traces of moisture and matter in suspension.

The oil was pale yellow in colour and had a pleasant odour.

The average results of duplicate determinations for the more important analytical constants are shown in the following table.

Oil.

Specific gravity at 30°C (water at 15°C=1)	...	0.9429
Refractive index at 27°C	...	1.4726
Saponification value	...	206.4
Iodine value (Wijs)	...	81.5
Acid value	...	1.0
Optical rotation (chloroform solution)	...	+47.9° at 29°C

Fatty Acids.

Solidifying point (Titer value)	...	39.1°C
Mean molecular weight	...	260.5
Neutralisation value	...	215.3
Iodine value (Wijs)	...	84.8
Optical rotation (chloroform solution)	...	+49.7° at 28.8°C

Remarks and Conclusions.

The low oil content of the fresh seed, 13.5 per cent, is due to the relatively high moisture content of the fresh kernel. With a normal moisture content of 10 per cent for the kernel the oil content of the seed would increase to approximately 16 per cent, a figure slightly below that recorded for this seed from other sources.

The trees from which the seed was collected are, however, only in the early fruiting stages and it is possible therefore that with an increase in age of the tree there may be a slight increase in the oil content of the kernel.

The figures for the chemical and physical constants of the oil and fatty acids agree favourably with those published by other workers.

A feature of the oil is the low acid value. In this connection attention is drawn to the importance of treating the kernels without delay if oil of good quality is to be recovered. Under estate conditions there should be no difficulty as regards this procedure but if seeds are left lying about before collection and stored without being dried there will be a considerable increase in the acidity of the oil.

As mentioned previously however it will only be possible to judge the full value of the oil from the medical point of view when some idea has been obtained of the relative proportions of the fatty acids present in the oil.

Received for publication 25th May, 1929.